IMPACT OF AIR INFILTRATION AND VENTILATION ON THERMAL COMFORT AND HEALTH

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Abstract

This paper presents the results of a research work of the indoor climate at 36 dwelling houses characteristics for Polish building industry. This work was realised in two phases.
The first phase has included a questionnaires. Inquires were made in order to find out the habits of the occupants, especially to the thermal comfort and indoor air quality.
In the second phase, the characteristic parameters for the thermal environment and for ventilation's action were measured.
The comparison of a large number of experiments on existing houses allows to name the main directions of continued works for elimination the excessive impact of air infiltration and ventilation on the indoor climate and energy consumption.

Introduction

The systematic increase of knowledge concerning the influence of environment on people's work and rest has been taking plce recently. A great standard of technical production and limitation of energy consumption brings about a discussion of the correct solution of a large number of problems. In this case, one of the important problems is the ventilation and air infiltration. From the energy conservation viewpoint, air infiltration and ventilation must be minimised. However, this can lead to uncomfortable or unhealthy effects on the occupants of such houses due to sources of indoor pollution (1,2). Unfortunately, this conflict is ignored in the Polish Norms. Recent fresh air requirements have varied from 15 m^3/h per person or 120 to 150 m^3/h for an apartment with cooking and bathroom occupancy. In this case, the ventilation rate varies between 0.5/h and about 2.0/h. The quantity of air is usually supplied by leakage in the building strusture, since most houses are ventilated by natural ventilation (3).

A theoretical and experimental study of these problems has been undertaken by the author since 1981 and continued recently. The basic aims were to define air flow mechanisms and estimate the influence of air flow on the indoor climate and on heat consumption. This paper presents some of characteristic results of this study for existing dwelling houses.

Scope of work and results

The basic research work was done in 36 dwelling houses characteristic of Poland and located in the Silesia region. They are built from prefabricated panels and are heated by district heating systems / with heat exchangers /. These eleven - storey apartment blocks are ventilated by the natural ventilation. For interior rooms, e.g., kitchens, bathrooms, or toilets exhaust ventilation (by the collective shafts - without fans) is found. The air ventilation - infiltration takes place not only through windows (or gaps around windows) and doors, but also through different joints in building structure.

The first aspect of this study - the estimation of the real state of indoor climate by the questionnaire. The questionnaire contains more than 30 questions. The questions deal with the persons' living in the dwelling, their age, health and smoking habits, dust, odour, temperature, humidity, air velocity, etc., and also the number of rooms and occupants in each dwelling, children, localisation of the dwelling in the block, etc. The basic questions are :

1. Do you find the quality of the air-- fresh or unisatisfactory ?
2. Do you find the air in the room - hot, warm, ..., cool, cold ?
3. Does the air feel - dry or humid ?
4. How does the indoor climate feel - comfortable or uncomfortable ?

These questionnaires were distributed to all dwellings and answers were received from 205 out of 224 dwellings, e.g, 91.5 %.

In the second phase of the research work the following parameters were measured : temperature fields, humidity and air velocity in the living rooms, kitchens and bathrooms, the quality of exhausted air, the quantity of air infiltrating through windows, doors, etc., the air change rate in rooms and dwellings. At the same time the measure of the carbon oxide concentration while utilization have been taken consideration and also - observation of the direction of air paths.

Description of the methods used and the particular results have already been presented in a previous papers (3,4,5,6). Therefore, in this paper the some of characteristic results for tested houses in winter and spring have been presented.

In order to obtain a result from the inquiry, computer analysis was made. This computer program worked through each question and wrote out a table of frequencies, mean values and standard deviation.

About 65 % of the occupants are younger than 40 years. Among the entire population are 31 % between 20 and 30 years old and 22 % younger than 15 years / children /. Distribution sex - age : 35 % of the woman are between 20 and 30 years old, 59 % of the woman are younger than 40 years.
The general results are :

- 55 % of the occupants are unisatisfied with their room air temperature
- thermal comfort is satisfactory only for 40 % of the occupants
- only 10 % are satisfied with the quality of air and about 65 % of the occupants belive that the indoor air is very dry
- 65 % are unisatisfied with the ventilation in the kitchen an 80 % with the ventilation in the bathroom

- most of the occupants are unisatisfied with their room air velocity, most of the complaints about draught are related to the living room - about 65 % of the answering occupants find it draughty there , for the kitchen the same number is 52 % and for the bathroom - 46 %

The characteristic results of the second phase of this study are pre-sented in Table 1. Except for values characteristic for ventilation's action / columns 3 - 1o /, some parameters of the indoor climate in dwellings located on the three levels of tested houses have been compared. It has been noted that great values of standard deviations have been characteristic for measurements. These cases of those values varying from average ones more than 2 σ have been frequent. As seen from Table 1 , the carbon oxide concentration has outvalued permitted one and also the air velocity, especially in the vicinity of windows (or balcony doors) has been greater thah allowed one. The kinetic energy of the air infiltrating is similar to the kinetic energy of convective flux of man's body (7) . Simultaneously, the average air exchange rate is 1.5 - 2.2/h. For indyvidual dwellings the air infiltration through a wall assembly varies between "- 45 m^3/h "/ air exfiltration - in upper part of houses / and about " + 150 m^3/h " / in the bottom dwellings /.

Finally, the results of measurements prove that there are accidental conditions in the dwellings. Similar results are obtained by the questionnaires. Therefore, the questionnaire used in this study can be basis for a dialogue with the occupants. In some cases measurements have been done, or just visual investigations.

Conclusions

Air infiltration and natural ventilation are important not only in the estimation of heating requirement and for energy consumption, but also in the determination of the quality of the air within the dwelling and the building. The best result of investigations on dwellings, living habits and health can be achieved by using questionnaires as well as visits and measurements. From the questionnaires dwellings with specific complaints can be elected for visits and measurements.

- The natural ventilation depends on such meteorological factors like the velocity and direction of wind and outer temperature. Those are the forces acting and simultaneously, the factors that deforme air - change.The majority of norms for buildings designed are irregular , especially for airtightness and the choise of ventilation systems

- Both the thermal comfort and indoor air quality and also heat consumption are depends on the level of tightening and ventilation actions. The basic way is the improvement of thermal insulation and airtightness in existing buildings. In this case, the limit of tightening must be determined as a result of the properties of all building components and influence of the weather factors and also the type of ventilation systems.

- In future dwelling houses these possibilities will be higher. They are connected not only with new buildind materials used , but also the correct solution of complex of problems which consist of indoor climate and the different strategies of energy reduction. This basic problem will be continue in the next research works.

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Table. 1. The comparison of average measured values and standar deviations in 36 examined buildings.

Season	Floor levels	Exhaust air (kitchens) Arithmetic mean $\dot{V}$ [m³/h]	Exhaust air (kitchens) Standard deviation $\sigma\dot{V}$ [m³/h]	Exhaust air (bathrooms) Arithmetic mean $\dot{V}$ [m³/h]	Exhaust air (bathrooms) Standard deviation $\sigma\dot{V}$ [m³/h]	Pressure differences (outdoor - indoor) Arithmetic mean Δp [Pa]	Pressure differences (outdoor - indoor) Standard deviation $\sigma\Delta p$ [Pa]	Pressure differences (stairway - indoor) Arithmetic mean Δp [Pa]	Pressure differences (stairway - indoor) Standard deviation $\sigma\Delta p$ [Pa]	Indoor temperature (living rooms) Arithmetic mean t_i [K]	Indoor temperature (living rooms) Standard deviation σt_i [K]
t_e=-4-0 °C, w = 1.5 m/s	1	74.0	10.5	55.2	9.8	+9.92	3.17	-5.64	2.21	18.1	1.4
	7	42.3	7.1	30.6	6.0	+ 1.85	0.92	+0.93	0.61	20.8	0.6
	11	67.1	8.8	50.8	10.2	- 3.90	1.77	+4.22	1.34	24.6	1.3
t_e=13-16 °C, w=4-6 m/s	1	31.0	11.2	31.1	13.4	+0.33	0.20	-2.21	0.99	17.8	1.2
	7	22.2	9.3	15.0	8.5	+0.88	0.62	+0.35	0.21	19.1	1.0
	11	35.0	13.8	31.0	19.8	+2.54	1.98	+3.28	1.22	19.0	0.8

Season	Floor levels	Air humidity Arithmetic mean φ [%]	Air humidity Standard deviation $\sigma\varphi$ [%]	Air velocity in the vicinity of windows (0.4 m) Arithmetic mean v_w [m/s]	Air velocity in the vicinity of windows (0.4 m) Standard deviation σv_w [m/s]	Air velocity (in centre of rooms) Arithmetic mean v [m/s]	Air velocity (in centre of rooms) Standard deviation σv [m/s]	The carbon oxide concentration after 30 min. exploatation kitchens and bathrooms [mg/dcm³]	Characteristic data of air flow by windows Coefficient a [m³/mh(Pa)]	Characteristic data of air flow by windows Exponent n —
t_e=-4-0 °C, w = 1.5 m/s	1	55.0	5.0	0.38	0.15	0.15	0.10	0.036	22.8	1.65
	7	35.0	5.2	0.15	0.05	0.05	0.05	0.092	4.3	1.26
	11	30.0	4.5	0.15	0.10	0.10	0.10	0.040	17.3	1.18
t_e=13-16 °C, w =4-6 m/s	1	40.0	6.0	0.35	0.15	0.05	0.05	0.048	19.7	1.53
	7	45.0	6.5	0.25	0.10	0.05	0.05	0.042	5.1	1.14
	11	50.0	7.2	0.54	0.25	0.15	0.15	0.029	28.5	1.13

A new Nordic standard proposal for measuring the thermal characteristics of clothing

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Abstract

The main purpose of most clothings is insulation like we insulate our houses to avoid too much heat loss. In hot, cold or neutral environments the thermal characteristics of the clothings worn will have an important influence on the heat exchange between man and environment. A new Nordic standard describing how to measure thermal insulation, air permeability and water vapour permeability has recently been proposed. This standard mainly deals with the measurement of the thermal insulation (clo-value) using a thermal manikin. By this method the influence of textiles, design, fitness, opening etc. is taken into account. These methods are not only for cold-protective clothing, but may be used for all types of clothing. The intent of this standard is that clothing manufacturers in the future shall use the standard and mark their products with the thermal properties.

Introduction

The thermal insulation of the clothing worn by people is an essential parameter when predicting the influence of the thermal environment on humans. In cold, neutral and warm environments the type of clothing worn will influence the heat exchange between the human body and the environment. This in turn influences the acceptability and stress of that environment. In warm environments clothing is often used to provide protection against the physical environment (dust, sparks, radiation) and may in some cases increase stress and reduce working time. However, clothing may also be used as protection against heat and increase the working time. In a neutral thermal environment clothing has a significant influence on the preferred ambient temperature. For example a change in thermal insulation of ~ 0.2 clo will change the preferred ambient temperature by ~ 1.5°C for a seated person. In cold environment clothing is, in most cases, the only method for making the working conditions tolerable.

Recently a series of international standards for assessing the thermal load of workers at their job sites have been developed under the auspices of the International Organisation for Standardisation (ISO). These Standards include methods to be used in moderate Thermal environments (ISO 7730 (2)), and in hot environments (ISO 7243 (3) and ISO/DIS 7933 (4)). All these standards deal in one way or the other with the effect of clothing on human tolerance to the thermal environment.

Also a method for evaluation cold environments by the required clothing index (IREQ) has been proposed by Holmér (1). This method also depends on the knowledge of the thermal insulation of clothings.

There is therefore a need to know the thermal insulation of a clothing ensemble. Therefore a Nordic group has been working on a standard for measurement on clothings. The present paper presents in a condensed form the main